THE LOCATION OF THE HIGH-DENSITY BOUNDARY IN SATURN'S INNER MAGNETOSPHERE

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Extended Abstract

Electron density measurements from the Cassini RPWS Langmuir Probe instrument have identified a sharply-defined region of low plasma densities in Saturn's magnetosphere outside a dipole L-shell of ∼15. Gradients in the density profiles define a boundary identified as the plasmapause [Gurnett et al., 2010] that separates the region of higher plasma density from the region of very low plasma density. During seven consecutive high-latitude passes in the northern hemisphere from September through December 2006, Cassini followed a series of trajectories that skimmed along high-latitude magnetic field lines for several days. The orientation of these trajectories made it possible for the RPWS to detect modulations in the high-latitude auroral hiss emissions at a 10.6 hour rotational modulation rate [Gurnett et al., 2009] and for the RPWS Langmuir Probe instrument to detect modulations in the electron density profiles that were anti-correlated with the hiss emissions [Gurnett et al., 2010]. The strong and periodic modulations in the density profiles indicate that Cassini is passing in and out of a plasma region of higher densities. One example during this seven-orbit time interval is shown in Figure 1. The periodic modulations in the density profile are shown in the bottom panel and are clearly anti-correlated with the periodic occurrence of intense auroral hiss emissions shown in the upper panel. The highest densities in this high-latitude region are 0.1 cm^{-3}, two orders of magnitude greater than the lowest densities in this part of Saturn's magnetosphere but well below the densities seen inside Saturn's plasma disk [Morooka et al., 2009; Persoon et al., 2009].

Four of the Cassini orbits from October 29-December 9, 2006 follow a nearly identical trajectory in the northern hemisphere and make an ideal time interval to study the organization of the density boundary crossings with longitude and radial distance, minimizing latitudinal variations. We use the newly developed SLS4-N longitude system for the northern hemisphere (see Gurnett et. al., [this issue]). In this time interval, the SLS4-N longitude system organizes the data very well, implying a rotational modulation rate of 816 ± 2 deg/day. The higher density regions are

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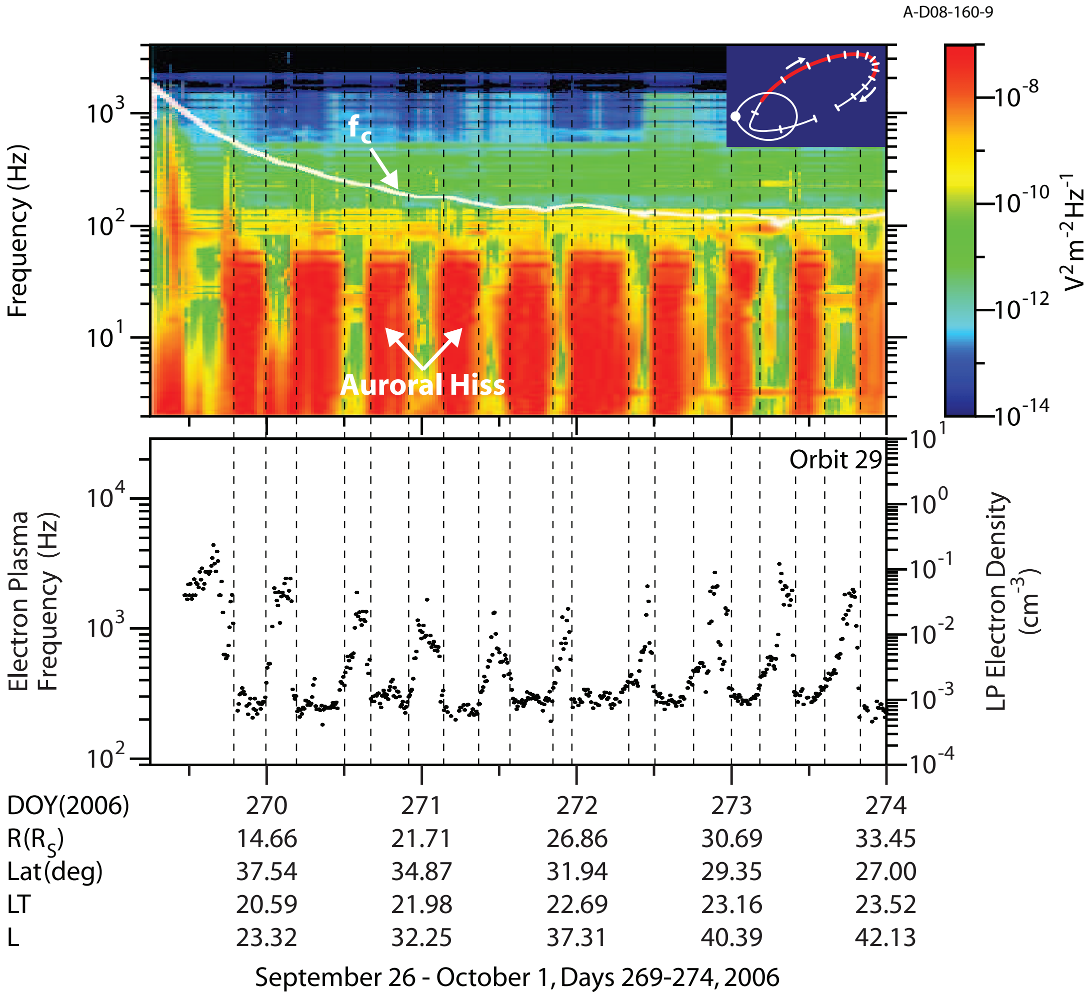

Figure 1: An outbound high-latitude Cassini pass in late September 2006 is shown in the upper right hand corner. The top panel shows the electric field spectrum of the periodic auroral hiss emissions for this pass and the bottom panel shows the corresponding modulated electron densities from the Langmuir probe. The auroral hiss emissions and the electron densities are clearly anti-correlated.

consistently found near 180° longitude. However, there can be substantial differences from orbit-to-orbit. The density boundary crossings during the first orbit in the sequence, shown in Figure 1, only produced consistent results using the SLS4-S longitude system for the southern hemisphere, implying a slower rotation rate of 798 ± 1 deg/day for this one interval only.

To determine the modulation period of the plasma inside the density boundary, the density data were normalized and averaged in one-degree longitude bins for a series of assumed rotation rates over the 88-day interval from September 26-December 23, 2006. For each rotation rate ω, the averaged values in the longitude bins were fit to a sinusoidal function of the spacecraft longitude, $A\sin[\lambda_{sc} - \phi]$, where A is the amplitude, λ_{sc} is the spacecraft longitude, and ϕ is the phase of the modulation. The assumed rotation rates ranged from 790 deg/day to 830 deg/day. The sinusoidal fits, plotted as a function of the peak-to-peak power derived from the amplitude, are shown in Figure 2. A rotation rate of 817 ± 1.68 deg/day is derived from a parabolic fit to the data points near the strongest peak of the spectrum (red dots). The result is consistent with the rotation rate for the periodicity of the Saturnian kilometric radiation and auroral hiss emissions in Saturn's northern magnetosphere at high latitudes.

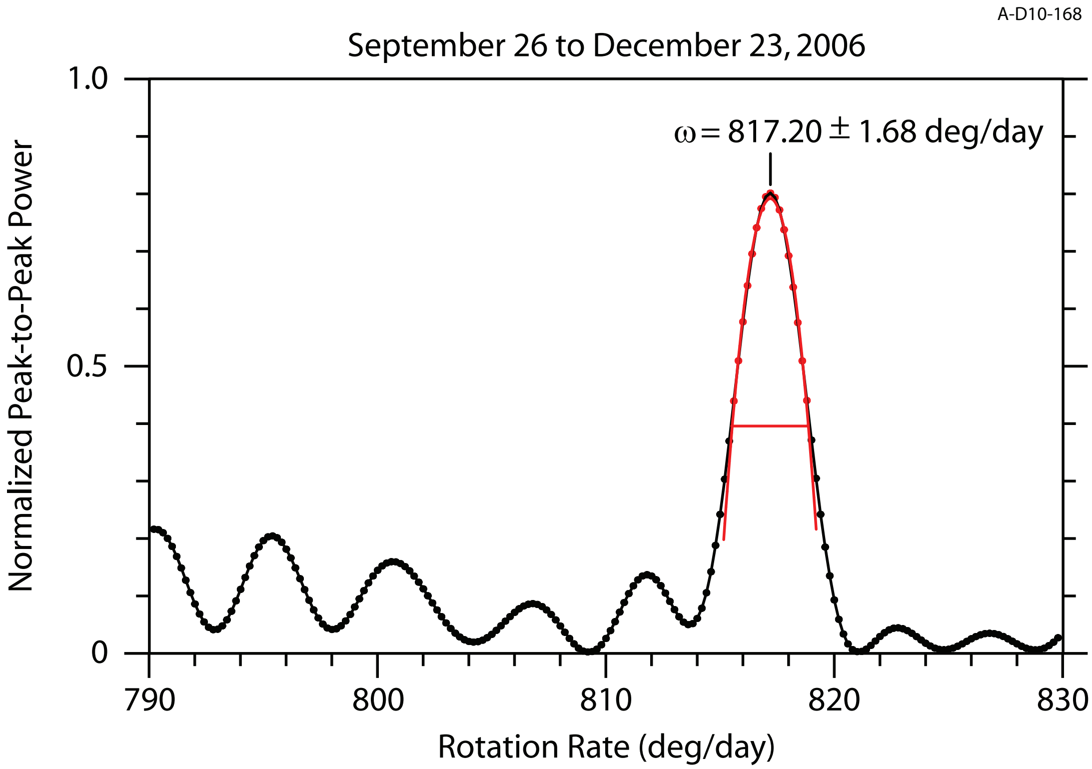

Figure 2: This plot illustrates the modulation power of the electron density as a function of an assumed rotation rate ω for a three-month period in late 2006. The SLS4-N longitude system for the northern hemisphere was used for this analysis. A plasma rotation rate of 817.2 $\pm$ 1.68 deg/day is obtained from a parabolic fit near the peak of the spectrum.

As indicated above, there are curious anomalies in the rotational periodicity rates on an orbit-to-orbit basis that currently defy explanation. However, when the data is averaged in longitude bins over months and years, there is a strong and consistent rotation rate of 817 deg/day for radio emissions and density modulations in Saturn's high-latitude northern magnetosphere.

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